“Microbial Degradation of Anionic Surfactant from Municipal and Industrial Wastewater”

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Submitted by

Jadhav Amol Shesherao

Under the guidance
Of

Dr. T. A. Kadam
Professor

School of Life Sciences,

Swami Ramanand Teerth Marathwada University,

Nanded-431606 (Maharashtra)

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Microbial Degradation of Anionic Surfactant from Municipal and Industrial Wastewater

Research Student: Jadhav Amol Shesherao

Research Supervisor: Dr.T.A.Kadam

Research Centre: School of Life Sciences, S.R.T.M. University, Nanded (MS).

Abstract:

Surfactants lower the surface tension between two liquids, between gas and liquid and between liquid and solid. Surfactants are main components in household and are used in industry. Surfactants and their products are discharged into the natural sources. Beyond the limit surfactants are present in municipal and industrial waste water. The effective removal of surfactant by biologically means from municipal and industrial wastewater reduces the harmful effect on aquatic plants, animal and human. Microbial consortia will help to reduce surfactant to acceptable level. Isolation and screening of bacterial isolates for degrading surfactant pollutant and potential consortia will be used to reduce the surfactant. Optimization studies will further augments helps to check the microbial degradation of surfactant. The microbial degradation of anionic surfactant will be characterized by GC-MS, UV-Visible spectroscopy, HPLC, LC-MS and FTIR.

Keywords: Anionic surfactants, wastewater, bacterial isolates, consortia, microbial degradation.

Introduction:

Surfactants have effects of solubilization, dispersion, emulsification, corrosion inhibition, biocidal properties, lubricity and viscosity modification (Wu et al. 2019). Surfactants are used in industrial, agricultural, pharmaceutical, food, cosmetics and household products (Wu et al. 2019).Surfactants and their products discharged into sewage treatment plants and then dispersed into the environment through effluent discharge into surface waters and sludge disposal on lands. Non-ionic and cationic surfactants are higher sorption on soil and sediment than anionic surfactant (Ying et al. 2006).The municipal wastewater treatment plants usually receive a high concentration of surfactants but release a low concentration of the surfactants and their degraded products upon secondary treatment (Badmus et al. 2021).

The damage degree of surfactant to aquatic plants relates to its concentration. Certain toxicity of surfactant passed into animal through animal feeding and skin penetration way. It affects gills, blood, kidney, pancreas, gall bladder and liver (Yuan et al. 2014).Surfactant in water can accumulates in the viscera of gills of fish, causing asphyxiation and death of fish, are

toxic to microorganisms in soil, can damage roots and inhibit photosynthesis in plants. It can cause harmful effect on human body and cause diseases such as dermatitis and ulcers (Wu et al. 2019).

Anionic surfactants (e.g.,linear alkyl benzene sulfonate) are degraded by *P. aeruginosa, P. nitroreducens, Serratia odorifera, P. putida, Acenetobactercalcoaceticus*. Cationic surfactant (e.g.,quaternary ammonium salts) are degradaded by *Psedomonas sp., Xanthomonas sp., Aeromonas sp., and Thalassospira sp.*For Non-ionic surfactants (e.g., Alkylphenol polyoxyethylene ether and aliphatic alcohol polyoxyethylene ether) *Pseudomonas sp., Cupriavidus sp., Moraxella osloensis, Brevibacterium sp.* are used. Amphoteric surfactants (e.g., quaternary ammonium salts) are degraded by *Psedomonas sp.*

The linear alkylbenzene sulfonate (LABS), alkyl ethoxy sulphate (AES), alkyl sulphate (AS), alkylphenol ethoxylate (APE), alkyl ethoxylates (AE), and quaternary ammonium-based structures (QAC) are the most sourced and used surfactants globally. The average surfactant concentration in domestic wastewater is from 10 to 20 mg/dm3, whereas in some industrial wastewater may reach even 300 mg/dm3 (Zhang et al. 1999).

Surfactants can penetrate drinking water through MWTPs, thereby posing a health risk to human, animal, and aquatic lives (Badmus et al. 2021). The fate and chemical structure of surfactants, environmental systems (aerobic or anaerobic), and electron acceptors contributes mainly to the persistence, degradability, and ecological effects of surfactants in the environment (Berge et al. 2017).

The presence of surfactants in aquatic and terrestrial environments poses an adverse effect on microorganisms, plants, animals, and humans. The immense usage of surfactants, their health hazards, and strict regulatory policies on their allowable limit call for their control in the environment. Several remediation approaches have been recommended for the clean-up of surfactants in the environment (Badmus et al. 2021).

The available remediation methods encompass the physical, chemical, biological, and membrane techniques (Siyal et al. 2020).Adsorption is the most common physical method due to its effectiveness in surfactant removal. Various materials are currently utilized as adsorbents, such as activated carbon, nanomaterials, zeolites, clay, and resin. Foam fractionation is a promising physical method to remove surfactants from wastewater (Burghoff, 2012).

The chemical remediation method provides an alternative to surfactant removal from waste systems.Coagulation is a very effective method (Naumczyk et al. 2017).Coagulation-flocculation is highly effective for the removal of pollutants in high concentrations (Naumczyk et al. 2017). Advanced oxidation processes (AOPs) have been proven as a promising remediation

method for recalcitrant surfactants. Electrochemical advanced oxidation processes (EAOPs) are alternative remediation technologies for anionic surfactants (Zhou et al. 2019).The biological treatment method shares the advantages of lower operational costs and the use of green methods. This technique involves breaking down large molecular weight compounds into lower ones using microorganisms such as algae, fungi, and bacteria

Therefore, the consortia of potential microorganisms isolated from waste water will be used for degradation of anionic surfactant from municipal and industrial waste water.

Review of Literature:

Surfactants are widely applied in industry, agriculture, food, medicine and other industries, which bring convenience to people, but also cause serious environmental pollution and even threaten human health.Microbial degradation of surfactants is an efficient, safe, environmentally friendly and widely applicable degradation method (Wu et al. 2019).

Non-ionic and cationic surfactants had much higher sorption on soil and sediment than anionic surfactants such as LAS. Ying et al. (2006) has reported that most surfactants can be degraded by microbes in the environment although some surfactants such as LAS and DTDMAC as well as alkylphenols may be persistent under anaerobic conditions. LAS were found to degrade in sludge amended soils with a half-life of 7 to 33 days. Most surfactants are not acutely toxic to organisms at environmental concentrations and aquatic chronic toxicity of surfactants occurred at concentrations usually greater than 0.1 mg/L. However, alkylphenols have shown to be capable of inducing the production of vitellogenin in male fish at a concentration as low as 5 μg/L.

Surfactants are widely used in various field of the national economy,will continue to expand its scope of application and the consumption is also increasing. The waste water containing surfactants inevitably is discharged into water bodies, and cause serious dangerous harm on ecosystems. The effect of surfactant on aquatic plants, aquatic animals, water environment and human body were studied by Yuan et al. (2014).

Badmus et al. (2021) has revealed the enormous ecotoxicity and human health implications of surfactants in the environment. The non-degradability, persistence, and toxicity of some surfactants and their transformed products have extreme environmental consequences. So, the balance and sustainability of natural ecosystems could be managed through assessment, practical analysis, and treatment of surfactants. Several analytical, assessments, and remediation technologies are been employed to effectively identify, quantify, and clean up surfactants from environmental matrices. Badmus et al. (2021) showed that chromatographic techniques particularly supercritical and quadrupole time of flight MS (Q-ToF-MS) fluid chromatography

offer a better analysis of surfactants up to trace level concentrations in environmental matrices. Considering the strengths and challenges of various available remediation methods for the surfactants, foam fractionation, thermal aerobic membrane reactors, advanced adsorbent, and electrochemical advanced aerobic processes are effective methods.

Khan et al. (2015) has been reported that *Pseudomonas sp.*, strain C505, was able to degrade BDDA and BDTA, individually and in mixture.Bergero et al. (2012) has been reported that the immobilized cells of P. putida A ATCC 12633 in Ca-alginate matrix and demonstrated the ability of this system to degrade the cationic surfactant TTAB.Analytical methodologies in the characterization and quantitation of non-ionic surfactants in cosmetics and environmental matrices are provided by Beneito-Cambra et al (2013). Due to their favourable physicochemical properties, non-ionic surfactants are extensively used in many fields of industry, processing technology and science, with a major usage in cleaners (Beneito-Cambra et al. 2013).

Kurrey et al. (2019) provides comprehensive information on the toxicity of surfactants, sources, sample preparation, analytical techniques, validation methods, and related problems in environmental samples of different composition and origin.Kurrey et al. (2019) also provides comprehensive information on the toxicity of surfactants, sources, sample preparation, analytical techniques, validation methods, and related problems in environmental samples of different composition and origin.The descriptions on determination of total concentration of ionic and non-ionic surfactants in various samples using various instrumental techniques i.e. potentiometric, colorimetric, spectrophotometric, spectroscopic and chromatographic related techniques owing to the simple and rapid measurement is also included by Kurrey et al. (2019). IR, GC-MS and HPLC have become excellent analytical tools for routine analysis of minute levels of various classes of SAAs in various samples with reduced detection limit (Kurrey et al. 2019).

Zhu et al. (2013) provides an overview of mass fluxes at the scale of a small catchment area by assessing the contribution of surfactants and biocides of a healthcare facility to the pollution transported within the sewerage system. Thus, for a small urbanized watershed such as this study site, the contribution of clinical discharges to the total flux was minor for the majority of surfactants. Siyal et al. (2020) considered only wastewater, the environmental fate and influence of these compounds from WWTPs, sludge should be considered in future. Accordingly, the mass balance of these surfactants should be conducted in order to study the life-cycle assessment of these compounds in WWTPs.

Objectives:

- Isolation of anionic surfactant degrading bacteria from municipal and industrial waste water
- Screening of bacterial isolates as potential anionic surfactant degrader
- Identification of potential surfactant bacterial degrader
- To analyse optimum parameters required for degradation of anionic surfactant
- To know ability for bacterial consortia of anionic surfactant degradation bacterial isolates at lab scale

Proposed hypothesis:

The microbial degradation of surfactant from municipal and industrial waste water will reduce the effect on aquatic plants, animals, microorganism and human body. The bacterial consortia processed waste water can be reused in agriculture as well as in industry as surfactant level from processed waste water can be reduced up to acceptable level.

Methodology:

1. Sample collection from municipal and industrial wastewater treatment plant.
2. Isolation of surfactant degrading bacterial isolates from municipal and industrial waste water by enrichment method.
3. Screening of bacterial isolates for potential anionic surfactant degradation by potentiometric and titrimetric method.
4. Identification of bacterial isolates by using molecular biology tools.
5. Optimization of anionic surfactant degradation using bacterial consortia.
6. Lab scale degradation of anionic surfactant
7. Characterization of biodegradation products by using GC-MS, UV-Visible spectroscopy, HPLC, LC-MS and FTIR

Importance of study:

The application of bacterial consortia as anionic surfactant degrading bacterial will reduce surfactant concentration from waste water and minimize the adverse effect of anionic surfactant on aquatic life viz. fishes, plant root, and photosynthesis function as well as protect normal ecosystem

National Status:

Varma, (2015) from Centre For Research, Anna University, Chennai (TM) had reported effluents of *Bacillus pumilis* MVSV3 for digestion of BTEX anionic surfactant.

Ambily et al. (2014) from School of Biosciences Mahatma Gandhi, University, Kerala had studied the anionic surfactant SDS digestion from the synthetic wastewater by free cell and immobilize cell's of the isolate *Ps. Aeruginosa*.

The significant portion of waste water being bypassed in STPs and sold to the nearby farmers of Delhi on charge basis by the Water and Sewerage Board. Few wastewater treatment systems are used such as bio-refineries wastewater treatment, municipal wastewater treatment using constructed wetlands, wastewater application methods and post-harvest interventions (Kaur et al. 2012).

International Status:

Wu et al. (2019) from China National Institute of Standardization, Beiging, Chiina. had studied the different mechanism for biodegradation of surfactant, the factors that affect biodegradation and methods of detecting Biodegradability . The microorganisms take surfactants as carbon source to carry out degradation reaction under the catalysis of enzymes in the following ways: ω-oxidation, β-oxidation, α-oxidation, and benzene ring oxidation.

Hosseini et al. (2007) from Department of Microbiology, Science and Research Campus, Islamic Azad University, Tehran, Iran had studied the degradation of anionic surfactant and found as resulted the *Pseudomonas beteli* and *Acinetobacter johnsoni* isolates were able to degrade 97.2% and 96.4% of the original SDS levels after 10 days of growth. Conclusion of this study suggested that the growth of simple bacteria such as *Acinetobacter* or *Pseudomonas* in household and industrial sewage can be cost effective method for anionic surfactants elimination.

Significance of study:

From present study, the consortia of anionic surfactant degrading bacteria will degrade surfactant from effluent of industrial and municipal wastewater treatment plant. The quality of effluent will be more superior in terms of less concentration of anionic surfactant and degradation of product. Hence, the effluent can be safely disposed into treatment can be study disposed into natural water bodies and environments. Sediment generated from secondary treatment can be safely disposed in environment. The wastewater after treatment with consortia can be used in agriculture safely or it can be re-used for industry.

Proposed work Plan:

Year-wise Plan of work and targets to be achieved:

Year	**Target to be completed**
First Year	❖ Coursework completion ❖ Review of literature &Sample collection ❖ Isolation of surfactant degrading bacteria
Second Year	❖ Screening of bacterial isolates for potential anionic surfactant degradation ❖ Identification of bacterial isolates
Third Year	❖ Optimization of anionic surfactant degradation using bacterial consortia. ❖ Lab scale degradation of anionic surfactant
Fourth year	❖ Characterization of biodegradation products by using GC-MS, UV-Visible spectroscopy, HPLC, LC-MS and FTIR ❖ Resulting and data analysis ❖ Thesis writing and submission to University

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Research student
Mr. Amol Sheshrao Jadhav

Research Guide
Dr. T.A. Kadam